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AUTHOR Fletcher, J. D.
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ABSTRACT

A literature survey of more than 800 sources, 80 of which were judged to be relevant, assessed the problems Native Alaskans and American Indians experience in learning elementary and junior high school mathematics, and focused on problems amenable to solution through computer presentation of mathematics materials. Empirical evidence indicated that American Indians are 1.7 years behind the national norm in grade 6 mathematics achievement and 3 years behind the norm at grade 12 and the proportion of Indian students with special needs in mathematics rises from 32% in grade 2, to 41% in grade 4, and to 46% in grade 6. Three clusters of problems American Indians experience with mathematics in school concern terms and concepts, time estimation, and student attitudes. Accordingly, it was recommended that computer presentations of mathematics materials to American Indians should provide practice on mathematics terms and concepts; include units on time estimation; and capitalize on the inherently motivating, "gaming" capabilities of computer interaction. The strength of computer presentation is its ability to provide practice that is: entertaining, motivating, and interactive; perceived to be culture-fair and private; easily transported and exactly reproduced; and individualized on an item-to-item basis. (Author/NEC)

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Please address editorial correspondence to:

Dr. J. D. Fletcher
WICAT Education Institute
931 East 300 North
Provo, UT 84601
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Abstract

Results of a survey to determine the problems Native Americans, Native Alaskans, and American Indians experience in learning mathematics are presented. Although the survey focused on problems amenable to solution through computer presentation of mathematics materials, the results should be of general interest and applicability. The research literature was found to be sparse, but three clusters of research issues emerged. These clusters concerned: mathematics terms and concepts; time estimation; and student attitudes. Accordingly, it was recommended that computer presentations of mathematics materials to American Indians should: provide practice on mathematics terms and concepts; include units on time estimation; and capitalize on the inherently motivating, "gaming" capabilities of computer interaction.

What Problems Do American Indians Have With Mathematics?[1]

J. D. Fletcher
WICAT Education Institute

This report documents a survey of available research literature. The survey was undertaken to determine the problems Native Americans, Native Alaskans, and/or American Indians, experience in learning the mathematics skills required for survival and success in a modern, technological culture. Over 800 sources were identified as being potentially relevant and of these about 80 were judged to be relevant to this survey.

The nature and scope of the report are governed by its purpose, and by the nature and scope of material available. With regard to purpose, the survey was to guide the adaptation and development of instructional materials for elementary and junior high school and mathematics presented by computer. For this reason, results reported here emphasize skill development areas that can be supported by computer presentations. With regard to the materials available, it should be mentioned that there are very few studies of any sort that directly discuss the problems that American Indian students, as a unique population, experience in learning mathematics. Many of the studies that did turn up were concerned with the vocabulary and language used to discuss mathematics concepts, not with the concepts themselves. One comes away from the survey with the impression that this is an area that deserved more attention from the research and development community than it has been getting.

There is empirical evidence that American Indians are having problems with mathematics in schools:

1. Bass and Tonjes (1970) report that dropout rates for Indian students are about twice as high as they are for the general population and that only 7% of Indian high school graduates complete college.

2. With regard to mathematics related fields, McDonald (1978) reported some recent efforts by the National Institute of Health to identify minority scientists in the biochemical fields. These efforts turned up less than ten Ph.D. scientists who were also enrolled tribal members. McDonald also reported that the last count of members of the American Indian Association of Physicians totaled only 22 medical doctors.

3. Green (1978) reported that a survey by the Bureau of Indian Affairs turned up only five American Indians who have doctorates in mathematics, only ten Indian doctorates in the physical sciences, less than 200 American Indian engineers, and less than 20 Indian engineers in computer fields. Notably, Green was not as disappointed by these scanty statistics as by the widespread fear and dislike of mathematics exhibited by American Indian students.

4. A United States Civil Rights Commission report (1973) found a steadily widening gap between the mathematics achievements of American Indians and national norms. The Commission found American Indian students to be 1.7 years behind the national norm in sixth grade and 3 years behind the national norm at grade 12.

5. Green, Kersey, and Prutsman (1973) in a study involving Seminole Indian elementary school children found median achievement in arithmetic to be over one standard deviation below national norms.

6. Mickleson and Galloway (1973) found that Canadian Indian 5 and 6 year old children were significantly behind their non-Indian peers in measured understanding of spatial concepts, quantity concepts, and time concepts.

7. A General Accounting Office report in 1977 found that the proportion of Indian students with special needs in mathematics rises from 32% in grade 2 to 41% in grade 4 to 46% in grade 6.

Despite these results and others like them, there seems little reason to attribute them to lack of mental ability. Levensky (1970) found that 1,700 Indian children who took a non-verbal test of intelligence achieved an average IQ of 101.5 which is slightly superior to the average of non-Indian children. On an earlier study completed in 1942, Havighurst and Hilkevitch (1944) administered a battery of non-verbal intelligence tests to a representative sample of Indian pupils from six tribes. These pupils scored an average IQ of 100.2, again slightly above the national average of non-Indians. Finally Kleinfeld (1973) pointed out that what "higher mental processes" are depends on what a culture values--one culture's higher mental processes may merely be another culture's stunts. In accord with this point of view, Kleinfeld found Eskimos to be far superior to other populations in figural abilities.

There is also reason to expect that computer presentations will improve the situation. Based on their use of computer-assisted instruction with Isleta Pueblo elementary school students, Suppes, Fletcher, and Zanotti (1975) estimated that one could expect an average Indian student gain of about 1.5 "years" in grade placement in mathematics computation over a full 180-day school year based on daily computer sessions of only 10 minutes. Hakes (1981) found that

100% of 23 5th grade Acoma Pueblo Indian students who received storytelling mathematics exercises on computer answered yes to statements like:

'I like the computer.'

'The computer helps me learn.'

'I wish we could have more time on the computer.'

'I like to work with my friends on the computer.'

The following discussion attempts to list specific problems American Indians experience with mathematics in school. These problems may not be unique to American Indian students, but in each case they have been observed in populations of American Indians. The problems are grouped into three clusters having to do with terms and concepts, time estimation, and attitude.

Terms and Concepts

By far the most work that has been done in the area of American Indian mathematics education has concerned mathematics terms and concepts. Incomplete understanding of English is most probably a barrier to high achievement in mathematics for American Indians. Studies by Rosier and Holm (1980) and by Bacon, Kidd, and Seaberg (1982) have shown that bilingual instruction (i.e. instruction that uses both English and appropriate Indian language(s) in the classroom) not only result in improved achievement in language related areas, but in mathematics as well.

Beyond this, however, it seems useful to ask if there are concepts and terms in mathematics as taught to American Indians that are uniquely difficult or simply unique for Indian students. This issue is best addressed in two studies by Douglas Garbe (1973 and 1978). This work was based on the notion that one source of difficulty for American Indian students studying mathematics is that

their concepts of some of the mathematics terms being used in class are not the same as those of their non-Indian peers. The two studies by Garbe support this notion. Based on empirical evidence obtained from two pilot studies, Garbe developed a list of 54 basic, high frequency mathematics terms. The pilot studies indicated that Indians were likely to choose different meanings from those chosen by non-Indians for these terms. Examples of these terms and their meaning choices are the following (the "Indian choices" are starred):

Multiplier

a) the number that is being multiplied

*b) the x in the problem $\begin{array}{r} 5 \\ \times 6 \\ \hline 30 \end{array}$

Average

a) what you get when you add some numbers and divide by how many you added

*b) the usual amount

Not equal to

a) different

*b) don't fit each other

Yard

a) 36 inches or 3 feet

*b) a stick 36 inches long used to find out how long something is

In the 1973 study, Garbe determined that when eighth grade Navajo students and their non-Indian peers were offered a choice in selecting the meaning of the 54 mathematics terms, the choices of the Indians and non-Indians differed significantly. Table 1, adapted from Garbe (1973), lists the terms he used, the percentage of Indians who selected the predicted Indian choice of meaning,

and the difference between these percentages. By examining the table, it can be determined that "Indian choices" for the following 12 words were selected by the Indians more than 35% of the time and differed by more than 20% from the choices of the non-Indians:

mixed numberal
multiple of a number
fraction
multiplier
average
not equal to
angle
hour
yard
definition
comparing
word problem

- -

Insert Table 1 about here

- -

Garbe's 1978 study was an extention and replication of this first basic study. In this second study, 40 non-Indian and 18 Navajo 6th grade students, 55 non-Indian and 41 Navajo 8th grade students, 48 non-Indian and 30 Navajo 11th grade students, and 22 non-Indian and 18 Navajo college students participated in a replication of the first study. The results showed that:

* at all four grade levels, selections by Navajo students of meanings for basic mathematics terms were significantly different from those of their non-Navajo peers.
* there were no significant differences between the choices of the Navajo in the 1978 study and those of the 1973 study.
* there were no significant differences among the choices of the Navajo students regardless of the number of years of schooling.

In addition to Garbe's two studies on mathematics concepts among Indians, two studies relating Indian world view and culture with mathematics concepts are worth mentioning.

1. Philipsen (1972) pointed out that notions of certainty and probability are not appropriate for the Navajo world view. This view is primarily wholistic, synthetic, and harmonizing. Philipsen's point was that notions concerned with level of certainty are analytical and disjunctive. The notion that "things" exist on a dimension scaled from false to true with levels of probability or certainty in between may come as a completely new and foreign idea to a Navajo student.

2. In a review of Navajo culture and mathematics, Moore (1982) asserted that the Navajo quest for unity, synthesis, and harmony is perfectly consistent with the views of professional mathematicians. However, he also found that there are no words in Navajo for 'multiply' and 'divide.' Further he found no agreed upon interpretation of 'if. . .then' English constructions in Navajo. It is clear that notions of 'multiply' and 'divide' come as a surprise to white, middle-class 3rd and 4th graders, but 'if. . .then' constructions seem to be part of Anglo culture from the craddle.

Time Estimation

Many non-Indian people who have worked with or lived among Indians speak jokingly of "Indian time." To some extent Indian tardiness may be a culturally based phenomenon. Downs (1972) points that among the Navajo for one individual to impose his will on another is the worst of bad manners and that this point of view extends to matters that non-Indians take for granted, most prominent among which is setting times for meetings. A Navajo's late arrival for a meeting may simply be a courtesy to prevent whomever set up the meeting in the first place from appearing impolite. On the other hand, it is interesting to note that three studies, each working with a different Indian tribe and population of Indian children found their subjects to be poor estimators

of time. The Mickleson and Galloway (1973) study was mentioned earlier. The other two studies are by Anderson, Burd, Dodd, and Keller (1980) and by Burd, Dodd, Smith, and Grassl (1981).

1. Anderson et al. showed cartoon strips with animal figures engaged in some activity from beginning to completion to 63 American Indian adolescents and 179 non-Indian peers. The subjects were asked to select among a group of choices such as 1 hour, 3 hours, 3 days, 2 months, and 1 year the time it would take to complete each task. The results indicated a significant difference between the two populations in estimating time to complete the tasks shown. The Indians' estimates agreed less frequently with adults' estimates of task completion times than did the non-Indians' estimates. Anderson et al. concluded that American Indian adolescents were less able than are non-Indian adolescents in estimating time in the same way as non-Indian adults do.

2. Burd et al. developed a 25-item multiple choice test that asks children to select an amount of time required to complete a given activity such as how long children sleep a night and how long it takes to tie a shoe. The test was administered to 172 3rd, 4th, 5th, and 6th graders in two almost entirely non-Indian schools and to 88 children in the same grade levels at an almost entirely Indian school on a Cheyenne Indian reservation. The non-Indian children scored significantly higher on the test at each of the grade levels tested.

The relationship between a quantitative ability such as time estimation and arithmetic achievement, or lack thereof, has yet to be established. Nonetheless,

the intuitive likelihood of such a relationship makes the time estimation difficulties of American Indian children of interest.

Attitude.

The fear and loathing that Green (1978) noted as characterizing the attitude of many American Indians toward mathematics, appears to represent a genuine problem. There seems to be no agreement on the causes of this problem. As Leap (1981) points out, the math avoidance problem has been attributed to general maladjustment of the tribal culture, the inadequacy of Indian English in expressing the abstract principles of mathematics, the verbal rather than visual orientation of schools, and the differences of Indian learning styles from non-Indian living styles. The solution to the problem seems to be equally elusive. Providing success experiences in mathematics would probably go a long way to alleviating the problem, but to do this would require a degree of individualization that will strain the capabilities of schools beyond tolerable limits. Interactive, individualized computer presentations may represent a major solution. In any case, mathematics avoidance remains a major problem for American Indians studying mathematics and adjusting to modern, technological culture.

Recommendations.

On the basis of the foregoing, what recommendation can be made for computer presentation of mathematics instruction to American Indian students? The strength of computer presentations appears to be in their almost infinite capacity to provide practice that is:

* entertaining, motivating, and interactive.
* perceived to be culture-fair and private.
* easily transported and exactly reproduced.
* individualized on an item to item basis.

Given these considerations and the survey documented above, it seems reasonable to recommend that computer presentations to American Indian children for mathematics instruction provide the following:

* They should provide practice on mathematics terms and concepts. Following the recommendations of Rosier and Holm (1980) and Bacon, Kidd, and Seaberg (1982) for a bilingual approach, explanations of these terms and concepts ought to be made in American Indian languages, using computer audio capabilities, as well as in English. Some of the terms identified by Garbe's studies (1973, 1978) and by Moore (1982) should be explicitly taught and practiced. Finally, stochastic notions of probability and certainty as discussed by Philipsen (1972) should be explicitly taught, perhaps sooner than they would ordinarily be in a non-Indian oriented mathematics curriculum.
* Some units on time estimation should be included. In the light of studies by Mickleson and Galloway (1973), Anderson, Burd, Dodd, and Kelker (1980), and Burd, Dodd, Smith, and Grassl (1981), it appears that some units should provide practice in estimating time needed to complete fairly common (to American Indians and others) tasks. The problem uncovered by these studies may be one of difficulty in breaking down tasks into their components and seeing the sequence of events needed to accomplish the tasks as well as estimating time for them. Providing practice in the techniques of problem solving analysis may be a significant step in helping American Indians acquire coping skills needed for modern society, and time estimation skills may be the best vehicle for this process.
* The computer presented materials should capitalize on the inherently motivating, "gaming" capabilities of computer interaction. The appeal

of using video gaming techniques to teach relevant and appropriate subject matter is hard to deny. The probability that this could be done successfully for mathematics instruction is very high. If Green (1978) is right and the primary obstacle to mathematics success among American Indian students is one of attitude, then the use of a gaming approach to teach mathematics to American Indian students seems almost mandatory.

In summary, and as stated earlier, this survey found the research literature on the problems that American Indians have with mathematics to be sparse. From one standpoint, this lack of research may be understandable. The problems that American Indians have with mathematics may be no different than the problems any group of children have learning mathematics in school. On the other hand, American Indians come from cultures and linguistic communities that are not based in Western European culture. What are the consequences of growing up in a culture where multiplication, division, and algebra are not part of daily life? What are the counting systems of the various American Indian languages? Do any of these counting systems use something other than base ten? What are the numerals used by the various native cultures? Do they all use positional notation? Answers to these and similar questions might reveal a great deal about how American Indians view mathematics concepts both in terms of their cognition and attitudes.

Leap (1981) sees these issues as central and, in fact, says:

> It is the organization of the underlying counting system and not the morphemic properties of the words used to express that system which needs to be highlighted in any inquiry into the mathematical skills characteristic of any tribe's traditional culture (p. 200).

Leap goes on to show that the Zuni Pueblo Indians use a counting system that is both base five and base ten, the Ponca Sioux most probably adapted their current counting system from one using base six, and that the Arikara language has vestiges of a counting system using base twenty.

The concluding point is that Indian mathematics is not just a linguistic phenomenon only to be understood in linguistic terms (again, Leap, 1981). What are needed are studies of mathematics in Indian cultures for which language may be only, but the only, key. Given information from studies of this sort, appeals for cross-cultural sensitivity would have specificity and focus, and would provide an essential contribution to solving the problems American Indians experience with school mathematics.

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Table 1

Mathematics terms used by Garbe (1973) and percentages of Indian and non-Indian answer selections

Term	Percentage of students who selected the predicted Indian choice: Indians	Non-Indians	Difference in Percentage
ten	25	8	17
four	31	16	15
six	27	14	13
eight	28	15	13
three	26	16	10
five	27	17	10
seven	25	16	9
nine	24	17	7
billion	23	18	5
mixed numeral	49	26	23
multiple of a number	50	28	22
fraction	36	15	21
odd number	71	53	18
tens	26	10	16
prime number	21	7	14
base ten	36	25	11
even number	54	52	2
multiplier	59	29	30
average	56	36	20
not equal to	37	17	20
half	31	20	11
total	23	15	6
product	39	35	4
greater than	41	46	-5
divide	22	28	-6
angle	37	9	28
vertical line	34	16	18
point	72	55	17
right angle	30	19	11
rectangle	17	8	9
diameter	18	9	9
line	44	36	8
cube	35	28	7
triangle	5	2	3
horizontal	28	28	0
parallel	50	52	-2

Table 1 (continued)

Percentage of students who selected the predicted Indian choice

Time	Indian	Non-Indian	Difference in percentage
hour	45	10	35
yard	43	17	26
square yard	61	43	18
area	76	63	13
height	54	44	10
length	16	11	5
measure	15	15	0
quart	72	82	-10
definition	46	14	32
comparing	67	42	25
word problem	39	18	21
sample	41	23	18
base	25	15	10
second	53	49	4
set	48	48	0
group	32	43	-11
empty set	37	43	-16
equal sets	47	67	-20

Footnote

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